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Walking the Integration Talk: An ArtSci Project

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Walking the Integration Talk: An ArtSci Project

Abstract
As teacher educators, we help prepare elementary generalist teacher-candidates (TCs) for traditional classrooms. In those classrooms, subjects are often taught in isolation rather than as integrated concepts and this practice is reflected in the program at the university where we teach art and science education. Because the world is multidimensional, interconnected, and complex, we created a project that integrates art and science learning as a way to prepare future teachers to provide relevant educational experiences for their students. Data, in the form of reflection papers prepared by the TCs, were analyzed using a grounded theory approach. Emergent topics resulted in four propositions that summarize the findings. They all speak to the value of an integrated education experience for TCs. This experience provides different opportunities for learning, offers cognitive "disruption", enables TCs to articulate pedagogy of integration, and can impact practice and program positively. In addition, three elements essential to an integration project at the tertiary level are identified.

En tant qu'éducateurs d'enseignants, nous participons à la préparation de candidats en éducation qui se destinent à devenir des enseignants généralistes. Dans ces salles de classe, les matières sont généralement enseignées isolément plutôt qu'en tant que concepts intégrés et cette pratique se reflète dans le programme universitaire où nous enseignons les arts et les sciences de l'éducation. Comme le monde est multidimensionnel, interconnecté et complexe, nous avons créé un projet qui intègre l'apprentissage des arts et des sciences d'une manière qui va préparer les futurs enseignants à fournir à leurs élèves des expériences d'enseignement pertinentes. Les données, sous forme de travaux de réflexion préparés par les étudiants en éducation, ont été analysées selon une théorie à base empirique. Des thèmes émergents ont été identifiés dans quatre propositions qui résument les résultats. Elles illustrent toutes la valeur d'une expérience d'enseignement intégré pour les étudiants en éducation. Cette expérience présente des possibilités d'apprentissage différentes et peut avoir des effets positifs sur la pratique et sur les programmes. De plus, elle identifie trois éléments essentiels pour préparer un projet d'intégration au niveau tertiaire.

Keywords
art education, science education, integration, grounded theory, teacher education

"Integration not only brings subjects together, but people as well." (TC group)

In most Western countries, art and science each have their own curriculum at the elementary and secondary levels, including specific content knowledge and cumulative skills. Art education explores traditional media (e.g., drawing, painting, printmaking, sculpture) augmented with design, art history, and criticism (Davis, 2008; Dorn, 2004). Holiday crafts are a popular focus at the elementary level (Karpinnen, 2008; Mason, 2005) and visual culture studies is a recent addition to art courses (Duncum, 2001; Freedman, 2003). If visual arts are integrated with other subjects, they are often blended with other arts (e.g., dance, drama, music) as a way of providing general arts education for learners (Cornett, 2011; Goldberg, 2012). Traditionally, science education has relied on textbook content knowledge, note taking, and pre-determined lab inquiries (Bencze, 2001; Gough, 2002; Hodson & Bencze, 1998). Recently, science pedagogy has been moving in the directions of student-based and inquiry learning, which acknowledge the creative elements inherent in science endeavours (Bencze, 2009). The STEM (science, technology, engineering, math) initiative promoting studies in those disciplines, however, largely downplays the connections that students might make to the humanities in general, and art in particular (Johnson, 2010).

Although both art and science involve questioning, critical thinking, experimentation, and creative problem solving, they are usually taught separately (Cornett, 2011; Donahue & Stuart, 2010; Edwards, 2008; Goldberg, 2012). At the elementary level, art and science lessons are often taught in their own weekly time slots and they are taught in their own dedicated classrooms in secondary schools. In faculties of arts and sciences at the post-secondary level, the departments housing the art and science courses are often separate. This segregation is supported by philosophical boundaries that, according to Edwards (2008), are "among the most formidable conceptual barriers standing in the way of idea translation" (p. 10). He criticized educational institutions (at all levels) that perpetuate a "silo" approach to learning and do little to create environments for integration.

In the school of education where we teach, all subjects are presented to teacher-candidates (TCs) in separate courses, yet we expound on the importance of integration because humans operate in contexts that are multidimensional, interconnected, and complex. Seeing subject segregation as a weakness in our program, we decided to create an opportunity for our TCs to experience an integrated art and science assignment to explore science education themes in artistic ways. Because our intention was to give both subjects equal status in the project, we refer to them interchangeably as art/science and science/art.

Edwards (2008) suggested, when art and science are blended, there is an opportunity for "catalytic synthesis" (p. 111) for the purpose of creating "new theories of science, forms of art, modes of cultural communication, and paths of innovative research" (p. 119). Similarly, Barone and Eisner (2012) argued the "borders between art and science are malleable and porous" (p. 7) and they advocated integration "to enlarge human understanding" (p. 8). In our exploratory study of art and science integration, the purpose was twofold: (a) to provide an opportunity for TCs to experience catalytic synthesis via cross-curricular blending, to think laterally across the "porous" borders, and to reflect on what they had experienced; and (b) thereby create for ourselves, as researchers, an opportunity to understand the process of integration as it applies to art and science education.

The following article begins with an overview of related literature on the subject, followed by our experience with integration. We then discuss the project, data collection, and analysis. Later, we discuss propositions arising from the analysis and provide our thoughts on essential elements for integration projects in teacher education and beyond.

Literature Review

When we first considered conducting a study of our science/art integration project, we based our knowledge of integration on our practical classroom experience supported with some theory. We, therefore, decided to research integration both generally and subject-specifically in order to broaden our knowledge.

The concept of integrating subjects is not new. According to Cornett (2011) and Goldberg (2012), integration was first recognized as a pedagogy in the late nineteenth century and has since had other labels. These include generative learning (Wittrock, 1992), real-life learning (Jones, Rasmussen, & Moffitt, 1997), cross-curricular learning (Barnes, 2011), and theme-based learning (Mumford, 2000). Cornett (2011) suggested, regardless of its labels, integration is about "combining diverse elements into harmonious wholes with a synergistic result" (pp. 15-16). Speaking specifically to integrating art and science, Bronowski (1956/1965), Dewey (1934), and Kuhn (1962) posited blending the two as a way of moving science forward. Kemp (1990) discussed how science influenced changes in art creation, while Florida (2002) and Pink (2006) advocated blending art and science to nurture conceptual thinking. Edwards (2008) used the term "artscience" (p. 7) which he defined as "the fused method...at once aesthetic and scientific – intuitive and deductive, sensual and analytical, comfortable with uncertainty and able to frame a problem, embracing nature in its complexity and able to simplify nature in its essence" (p. 7).

Despite the noted benefits of integration, some scholars have expressed concerns. Venville, Wallace, Rennie, and Malone (2002) found that teachers who implement integrative pedagogies were "unable to articulate clearly the advantages and disadvantages of integrated teaching practice and they rarely had a well-developed rationale for what they were doing" (p. 45). The implication is that the process of integration is not understood well by some educators since it represents a departure from traditional 'silo' approaches to subject areas.

Danko-McGhee and Slutsky (2007), Edens and Potter (2007), and Wilhelm (2004) suggested that art loses its skill integrity if it is taught solely as integrated with other subjects. Moreover, according to Venville, Sheffield, Rennie, and Wallace (2008) and Wallace, Sheffield, Rennie, and Venville (2007), as soon as science is integrated with a "soft" subject like art, its status in the education community (e.g., students, teachers, administrators, parents) is lowered. An art and science integration at the secondary level is further problematic since, as Venville et al. (2002) suggested, secondary schools seem designed to protect the separation of subjects, a position that does not lend itself to "integration and collaboration across subject boundaries" (p. 54). Traditional science pedagogies, consisting of lecture style note-taking and pre-determined laboratory activities, often value categorical and sequential thought processes that support content knowledge acquisition.

Yet the human brain is capable of rich learning through integration opportunities. According to Venville et al. (2008), "Knowledge in the real world is holistic, and the division of knowledge into subjects for teaching and learning in schools is an historical artifact and a pragmatic method of curriculum delivery" (p. 860). They suggest that pedagogies that strive to integrate learning, particularly in authentic contexts, support skills such as higher-order thinking, problem solving, application to real world problems, creativity and invention, and collaborative and individual learning. Root-Bernstein (2003) points to scientists who exhibited remarkable artistic abilities; Benjamin Franklin and Alexander Graham Bell, for example, were excellent musicians and composers. Neither is it surprising that learners are more engaged in their learning when it allows them to access their own life experience. From a practical perspective, it should not be overlooked that teachers' thoughtful use of integration can enable learners to engage meaningfully with multiple disciplinary expectations crowded into school curricula within tight time constraints.

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Our Experience with Integration

I (Liz) have taught elementary, secondary, and pre-service art education for over 26 years, and often integrated subject areas. When teaching at the elementary level, I blended art with language and social studies; physics and chemistry concepts were blended into my secondary media arts and photography classes. Currently, I use integration to model cross-curricular approaches and boost art confidence among generalist TCs; for example, they blend art knowledge learned in my classes with their various subjects of expertise. Despite years of experience with integration, I had never worked with another educator to share the subject integration process. The science/art project provided that opportunity.

I (Astrid) have been an educator in alternative and formal programs, and now teach pre-service science methods. My diverse background in education has taught me that learning is best done in context, and contexts are rarely associated with a single discipline. Science as a discipline traditionally sets itself apart with specific and complex bodies of knowledge and skill sets. That inaccessibility has translated into TCs who feel anxious and lack confidence about teaching science at the elementary level. I have come to believe that by integrating science studies with other subject areas, TCs develop clarity about how science works, the knowledge it makes available to us, and how science "fits" socially, culturally, and politically. Sharing an integrated assignment with another professor, rather than keeping it within my coursework, made sense as it allowed us to model concepts that we (and our colleagues) advocate: integration of lessons, opportunities for differentiated learning, higher thinking skills, problem solving, critical thinking, and collaboration.

While there is considerable literature addressing the value of integration in general, and support for blending art and science specifically, there is little regarding integration within post-secondary education. Upon examining existing literature and our personal ideologies about integration, we looked at the pre-service program in which we teach to determine what forms of integration might exist and whether a cross-disciplinary integrated project was possible. Indeed, we found that there were not many opportunities for TCs to practice integration in their education studies. Generalist TCs must complete foundation courses in methods and psychology and take subject specific courses (e.g., art, health and physical education, language arts, mathematics, music, science, social studies) that mirror the "silo'" approach in Ontario schools. The result is a full program wherein each professor focuses primarily on his/her area of expertise.

Venville et al. (2008) stated, "An integrated curriculum enables students to look toward multiple dimensions that reflect the realities of their experiences outside and inside school" (p. 860). We believe this speaks directly to the experiences of our TCs as they learn to teach in a wide variety of subject areas, internalizing their own learning as well as considering the learning of their future students.

Methods

When we conceived our art/science integration project in spring 2011, we were fortunate to have in place factors supporting the implementation of integrated projects amongst collaborating educators. Venville et al. (2008) identified these factors as: school organization, classroom structure, timetables, teacher qualifications, collaborative planning time, and approaches to assessment. Added to this list are those identified by Wallace et al. (2007): a shared purpose for education between educators, administration and community; the valuing of, and respect for, collegial relations; the commitment of educators to improve their practice; and organizational structures that support the logistics of integration, including teacher planning time and available resources. The factors most influential to our program were: a shared belief that integrated learning is powerful, a desire to

explore integration as a means to improving our personal teaching practices as well as our shared education program, and a supportive administration to structure a timetable conducive to integration.

The art/science integration assignment, which was the basis of our research, involved the participation of 134 TCs (consecutive and concurrent) in the Junior/Intermediate (J/I) division (TCs preparing to teach learners ages 9 to 16) who self-selected into 35 groups of two to five persons per group. The assignment consisted of three parts: (a) the creation of a "fishbone" graphic organizer (see Figure 1) to analyze a J/I science education unit (Ontario Ministry of Education, 2007/2008) in terms of its science and technology content, with implications for society and environment; (b) an art construction in any medium, based on provincial J/I art expectations (Ontario Ministry of Education, 2009/2010), using recycled materials, expressing one or more themes of the science unit, and housing the organizer information; and (c) a reflection paper (2-3 pages) prepared by the group, focusing on art and science integration in general and suggesting specific considerations for the TCs' future classrooms.

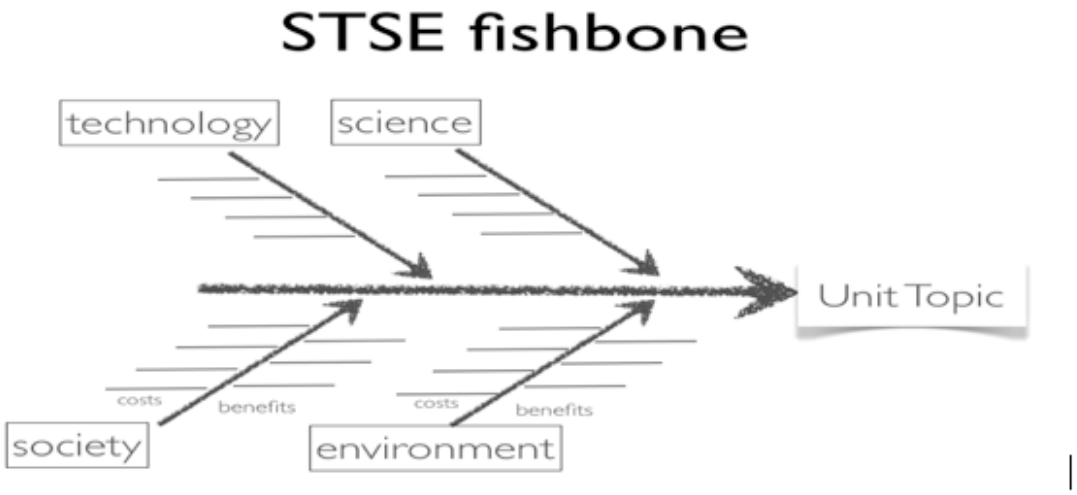

Figure 1. Science Technology Society Environment (STSE) "fishbone" graphic organizer.

Prior to the assignment, the TCs learned basic art skills, as well as design elements and principles. In their science education class, they developed enough familiarity with science curriculum to choose a unit and complete the graphic organizer. The TCs then had approximately one month to complete their science/art integration assignments.

We focused solely on the reflection papers for our data and analysis because we felt it was the most useful segment of the assignment for understanding how TCs engage with integration. The reflection papers provided insight into the TCs' thoughts and thought processes as they worked on the project and were guided by two questions: (a) How well are specific curricular expectations met (or not) through the integration? and (b) What are some of the classroom considerations for an art/science integration? We believed the first question would help us determine TCs' levels of understanding of curriculum connections within and between each subject and the second would furnish a view of the TCs "thinking like teachers." As well, we hoped these questions would provide the opportunity for the participants to reflect on their experience with integration and extrapolate on it for their future students. We requested that group members discuss, and come to agreement on, their responses within the reflection papers. Their discussions occurred at various times while they worked on their projects, both in and outside of class time. The TCs understood that our analysis of their reflections would not commence until after all marks for the project had been finalized, and

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further, that at the point of analysis, all of the reflections would be anonymous (e.g., we removed all identifying features from their papers).

Based on the open-ended qualitative data we collected, we decided to use a constructivist grounded theory approach (Charmaz, 2006; Creswell, 2013) as it provided a framework to organize and code our analysis. The coding process, as described by Charmaz (2006), is a reflexive process in which emergent topics reflect both the values and beliefs of the TCs, as well as the perspectives of the researchers. At first, we worked separately to identify ideas we found compelling in the data; then we worked together to arrive at topics that could be further dimensionalized through examples. In our analysis, we realized the TCs not only answered the two questions posed to them but also offered their views on other issues they perceived could impact integration efforts.

Data Analysis

The two guiding questions for the reflection papers were a point of entry to data analysis because they provided initial topics. While the second question, addressing practical aspects of classroom integration, received broad and insightful responses from the TCs, the first question, addressing specific curricular expectations, was not received well. TCs' answers were sparse and did not address specific expectations in any depth. The question itself was likely a weak construct and so we were happy to discover that the TCs wrote at length about other issues they deemed important.

Below, we present topics arising from TCs' responses to the reflection questions. We begin with their general thoughts about integration as pedagogy, then narrow the focus to specific issues raised from the questions and beyond. Quotations come directly from the reflection papers; however, since there is no way to attribute specific comments to any single individual, no sourcing is provided.

Topic: Integration as Pedagogy

Many TCs took a holistic view of art/science integration and acknowledged the importance of enabling students, as two groups wrote, to "express their learning in a way that they understand it – this allows for transformative learning" and "when education becomes self-directed it broadens students' worldviews and self-concepts". Another group wrote, "Students need to be able to think creatively and critically in order to ensure they can make positive contributions to the global community". Yet another group suggested integration was "especially meaningful for the 21st century classroom so that students see a connected world". They reasoned, because integration is part of their daily lives, it should naturally be part of education.

Some groups remarked on the integration of science and art as being "unusual," since their personal experience was one of contrast and dichotomy; that is, a person is either an 'artsy' or a "sciencey" type. Yet, as they worked through the integrated project, the TCs realized the creative process is as relevant to science as it is to art. As one group wrote, "the creative process is where the students brainstorm and contemplate their ideas and make their vision into a physical reality". Working with a science unit on form and function, another reflected, "The tricky part was to design [the art construction] in such a way that it was functional but also held aesthetic appeal."

Overwhelmingly, the TCs reported their integration experience as being authentic and meaningful because it required higher order thinking, ingenuity, and a sophisticated applicability of both art and science knowledge. They found many connections between the science and art curriculum expectations (Ontario Ministry of Education, 2007, 2008, 2009, 2010), saw advantages in integrating them, and considered integrations with other subject areas. One group wrote, "Scientific inquiry is also an artistic inquiry…demonstrate curiosity, ask questions and answer them through experimentation, create plans, express ideas, identify patterns and draw conclusions… explore and

create." It seemed the integration experience enabled many students to recognize curricular connections and realize how strong these could be.

The reflections often included considerations of how integration might impact their future students, and they demonstrated their professional development by taking the perspective of future educators. One group wrote, "learning through art might mean that facts have more impact…A student may struggle in science but will enjoy the content more if it is presented in the context of a visual arts activity". Another suggested some concepts are represented and understood better through pictures and models: "Art helps more visual students explain what they are thinking in science when traditional means (essays, tests, quizzes) are not as effective". Yet another reflected that science/art integration created "an emotional environment wherein students will retain information". This was a direct connection to a previous science lesson on how brain-based research made strong connections between emotion and learning (McGeehan, 2001).

The art/science project was deemed beneficial by the TCs for students identified with learning exceptionalities since the project did not require adherence to what one group described as the "stifling parameters" of traditional projects. Some suggested that in any integration assignment, learners should have considerable freedom of choice by providing learners with wide parameters for science topics, plenty of scope for experimentation, and choice of art media for presenting their topics in visual ways. According to two groups, this would give learners "creative license" and "to use the full potential of their creativity while practicing the scientific method". Another group added, "students need to learn...skills like: teamwork, creativity, independent thinking, higher order thinking and character education". As well, one group implied that integration supported learners' social development by "promoting a new dialogue amongst students who may have extremely different interests and backgrounds".

Topic: Content Knowledge

Some TCs suggested learners should have basic content knowledge in both subjects before integrating them; for example, have the opportunity to research science topics using various resources, and have some practical experience with a variety of art media, before starting the project. One group suggested the project could fulfill the requirements of both subjects in different ways and at different points in the learning process:

> We would use the science aspect of the assignment as an exploratory introduction to a new strand or unit. This would encourage transformative learning and allow students to become more fully engaged in their lessons. The art aspect would serve as a cumulative evaluation piece for a teacher. It would be a chance for students to showcase knowledge of the elements and principles of design already practiced in previous lessons.

This comment reminded us that all of the TCs were not necessarily at the same level of learning in their art and science education classes. Some groups, for example, had not understood or completed the science portion of the assignment and, therefore, used art studio time to do so, resulting in lack of art time to work on their constructions.

Certainly, timing seems to be an important factor in planning and implementing integrated projects. Some groups assumed the integration would occur at the end of a course as a culmination of material already learned, whereas others took the integration to be a suitable vehicle for exploration and learning at the beginning or in the middle of a course. One group suggested integration allowed for "trial and error" learning and felt this could be an effective teaching and learning strategy throughout a course. Indeed, research done by Kapur (2010) on "productive failure" demonstrated

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that students working on complex problems without support or scaffolds until nearing the end of a project nonetheless exhibited higher conceptual understanding of content material.

Because the project took place in the last semester of teacher training, the TCs were familiar with the breadth of the Ontario elementary school curriculum and were beginning to realize integration was not only desirable but also necessary to help learners meet multiple expectations in any given year. One group wrote:

> By adjusting the assignment, it is possible that more of the curriculum can be covered… having students complete a written assignment…and reflecting on their experience…would cover more of the reflecting, responding and analyzing...expectations from the art curriculum.

Similarly, other groups reflected on the potential for expanding the art/science integration to help learners meet expectations from language arts, mathematics, and social studies.

Topic: Disciplinary Balance

As we analyzed the reflections, we realized some participants identified the potential issue of one subject, art or science, emerging dominant in the integration. There were a number of comments on the importance of science over art, or vice versa, with concerns expressed that art was in the supporting role. One group's phrase, "students express their knowledge of science artistically", implies science concepts are supported through doing art. Indeed, another group admitted art was supporting their learning in science, and they made a conscious decision to work within the project in that way. A number of groups, however, felt strongly that there should be a balance of both art and science, and considered how to address this. One group wrote, "Each curriculum should be represented equally…Without a balance the artwork may dominate or…[the project] might end up simply looking like a science fair project", and another group wrote,

> Students might be inclined to focus more on one aspect of the project (e.g., art) while neglecting the other part (e.g., science). This can be avoided by providing students with clear objectives and rubrics so that they know that both art and science are being evaluated. The teacher should monitor students too, just to make sure they maintain the balance between both subjects.

Although these were valid concerns, we clarify, for their assignment the TCs were provided with a detailed rubric, including separate sections for the science and art segments, plus a combined rubric for the group reflection paper. Nonetheless, we were pleased some reflected on the need for balance between subjects if/when they created integrated assignments for their future students.

Topic: Assessment and Evaluation

Those who included comments about assessment and/or evaluation suggested that learners participate in creating assessment tools by assisting to establish the criteria for success. As well, they advocated the incorporation of both art and science components in the assessment/evaluation process. According to three groups, "Ideally the class would be part of co-constructing the success criteria to encourage students to be more accountable and invested in their work", "assessment needs to identify both art and science expectations", and, "success criteria should be posted so students can refer to it". While these suggestions are pedagogically acceptable, and are based on the teaching and learning on assessment in our program, we felt that the data on assessment derived from this project

was limited. We view assessment and evaluation as extremely important aspects of teaching; they are complex processes and likely problematic for integrated assignments. One group stated, "in our program we do not focus enough on issues of assessment"; this statement may explain the limited number of responses addressing assessment and evaluation in the reflection papers.

Topic: Classroom Considerations

Many TCs addressed the logistics of doing an integrated project with their future students. These included concerns about classroom management, access to supplies, along with time and space requirements. Regarding potential management issues, one group wrote:

> Student behaviour should be taken into consideration as this project involves an abundance of independent work. The teacher should have a solid grasp on classroom behaviour patterns ... to avoid any problems. The assignment can be altered to encompass less individual work if the teacher is not confident with…class behaviour.

Related concerns included dysfunctional group dynamics and students with differing abilities requiring accommodations. It was suggested the teacher provide accommodations for learners during all steps in the integration process and, perhaps, cluster group members based on their strengths. Furthermore, TCs suggested group members be able to choose and/or delegate project duties to divide project work equally among learners. Additional management considerations found within the reflection papers included safe use of tools and proper clean up procedures when using messy media in classrooms without sinks. Other classroom considerations included sufficient space for safe construction and storage of artworks.

Concerns about supplies were discussed by some groups who suggested integration assignments might be enhanced - or hampered - by cost, availability, and logistics of obtaining and using materials, tools, and technology. One group suggested using available tools (rather than purchasing new ones), as well as recycled materials, to build the constructions as this would promote an attitude of sustainability among learners. As one group stated, "It is important to note that students may not be able to purchase their own craft items...requiring that the students complete the construction with recycled items is a cost effective option". Many groups appreciated the significance of using recycled materials for their art constructions as a way of supporting environmental education. They felt the integration assisted in viewing environmental sustainability as an overarching theme in education programs. The importance of out-of-classroom learning was connected to the project by a group who suggested a field trip to a recycling plant as a scientific connection to the use of recycled materials.

Most TCs recognized the extensive time required for planning and implementing an integration project. One group wrote:

> This project [was] time-consuming...it took us several days to complete, where we worked for several hours on it at a time; therefore, it is our suggestion that teachers…make the construction smaller and narrow it to fewer [science] issues for students to focus on, or make it part of a larger culminating project and set aside a significant amount of time for students to complete it.

They, along with other groups, suggested time should be allotted in both art and science lessons, ideally having equal time and emphasis in both subject areas.

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Topic: The Teacher

It was of interest to us that many TCs identified the single most important factor limiting integration as 'the teacher'. They suggested it falls on the teacher to see opportunities for an integrated project, to plan for it, adjust it, and carry it through. As one group wrote, "Application of cross-curricular activities in the classroom can be as simple or as vast as the teacher's imagination". Conversely, the teacher becomes the limiting factor in an integration project if he/she lacks imagination and creativity, and/or has a strong personal focus in one subject area. As an example of this, all of the members of one group had very strong science backgrounds and all admitted to a general lack of creativity. Indeed, they felt unable to create a "creative" art piece, instead constructing a precise three-dimensional model of a cell. Moreover, this particular group was unable to reflect deeply on the role of art in science and struggled with the integrated project.

Most groups voiced concerns regarding subject knowledge and cooperation, suggesting if a teacher implemented a similar art/science integration project, and he/she did not have significant knowledge of one of the subjects, the assignment may be focused more on one subject than the other. Or, if more than one teacher was involved with the assignment, potential problems could occur. One group made the following suggestion:

> If there are different teachers for each of the subjects, it is critical that both teachers are well-informed and on the same page about the assignment...this open communication between both the science and the art teacher will be vital to student success with the project.

Some participants, however, pointed to the value of building skills in teacher collaboration. One group noted, "There was a lot of problem solving and critical thinking that took place…we had to work together, divide up the tasks and use our time wisely", and, "Our group felt that an assignment like this really helps build teamwork and collaboration skills that are crucial for becoming a teacher".

We were pleased with the range of ideas and the depth of vision the TCs shared in their reflections. Because they are professionals in training, it was instructive for us to see they were thinking in both practical and pedagogical terms. We appreciated their inclusion of comments on topics like sinks, storage, and supplies. Successful student activities depend on both the teacher's pedagogical as well as practical knowledge, as well as the physical space within which they must work. Thus, we felt that these comments, while not of a highly scholarly nature, indicate the TCs were taking stock of the broad requirements of integrative student activities.

Limitations

We identify here a number of weaknesses in the study. First, project participation was limited to TCs in the Junior/Intermediate program, which represents one third of the TCs in our school of education. Missing from the data are the perspectives of TCs in the Primary/Junior and Intermediate/Senior divisions, given the elementary and secondary panel differences identified by the TCs and corroborated in the literature (Venville et al., 2002/2008). In addition, our data from concurrent education TCs, who may offer additional perspectives given their extended studies in education, is minimal.

Second, the analysis is based on one data source: the reflection papers. Our conversations amongst ourselves and the TCs, and our observations made throughout the project, were not recorded, and thus remain anecdotal oral narratives. In addition, we did not analyze the art constructions because we had not designed our research to incorporate these. We realize, however, our positive reactions to these constructions most certainly must have influenced our analysis of the reflection

papers, although we cannot specifically identify those influences. Charmaz (2006) recognizes such reflexivity will indeed occur, and thus we viewed the non-formalized data through a lens of reflexivity, with the understanding that it would inform our analysis. In future research, we would consider widening our scope of analysis to include the formal collection of data from multiple sources, as well as our emotional responses to the submissions.

Third, since the study was spread over more than one semester, the project sequence and instructions for students in the second semester were much smoother, resulting in differing experiences for TCs in each semester, and likely impacting their reflections. We received feedback from the TCs that communication between instructors was very important, thus underscoring how much easier integration is with one teacher in an elementary classroom rather than with two or more teachers in secondary and/or post-secondary classrooms.

Last, we address the question of privilege between art and science. We believe the project worked well for making science more noticeable/visual, but we question if it made art more scientific. We did not, for example, see much evidence of creating art scientifically, other than a few isometric drawings, planning notes, and measurements. This continues to be a talking point for us.

Although the list of limitations seems lengthy, we believe the data provides useful information as a starting point for developing theory on integrative practices at not only our school of education but also in other post-secondary programs. As such, we view our project as an exploratory study upon which we can build in subsequent years, and thus take this discussion of limitations to be instructive for our next iteration of the project.

Discussion and Recommendations

We stated at the outset that our purpose was twofold: (a) to provide an opportunity for TCs to experience a cross-curricular blending of art and science education, and (b) to create for ourselves an opportunity to understand the process of integration as it applies to art and science education. The data we collected provided strong evidence that the first goal was met: the TCs experienced the integration of science and art education and provided reflections for analysis. Moreover, the second goal was met as we encountered a variety of topics ranging from practical aspects, to limitations, to the value of integration for future students.

As suggested by Charmaz (2006), the outcomes of grounded theory research are better presented as propositions than irrefutable conclusions. To this end, we distilled the topics generated by the analysis into four propositions that, in turn, provide points of departure for further discussion addressing pedagogies of integration.

Propositions

1. An integrated assignment provides different opportunities for TC learning.

The quote that began this paper, “Integration not only brings subjects together, but people as well”, describes the experiences of most TCs as they worked together on their integrated assignment. They spent time creating, discussing, and reflecting amongst themselves, thereby creating an opportunity for learning through social collaborative activity (Vygotsky, 1978). We posit that their learning was enhanced because they experienced integration directly, providing the impetus to think more deeply about incorporating it into their future professional practice. In addition, the integration assignment provided many of them with contextual opportunities to “think like a teacher” about practical classroom considerations.

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Although our focus was on TCs' understanding of their assignment, we suggest integrated experiences may be valuable for other learners at different stages in their education. If, for example, elementary and/or secondary learners participate in integrated activities, they may feel more comfortable with the concept and practice of integration as mature learners. As well, post-secondary learners, especially those in professional programs outside of teaching, may find integrated projects helpful for practical and conceptual learning opportunities.

2. An integrated project provides a cognitive 'disruption'.

Edwards (2008) states, "Artscience...produces disruption and helps us creatively respond to it" (p. 143). We found our integration project produced disruption for the TCs as it challenged some of their established perspectives and practices in education. It seemed to augment their content knowledge of both disciplines, helped them see specific themes and issues with a fresh eye, and raise new questions, all leading to a shift in most groups' perspectives from art and science as dissimilar subjects to two that blend nicely.

As teacher educators, it is valuable to us to realize that the integration project has an element of disruption. The TCs must learn to do more than simply recreate the pedagogies with which they are familiar and comfortable and it is our aim to inspire TCs to become innovative educators receptive to new ideas. Indeed, a disruption of our own practice is a welcome reminder that we also must remain open and innovative in our respective fields of expertise.

3. The exercise enabled TCs to articulate pedagogy of integration.

The TCs' reflections were, in many cases, very detailed descriptions and analyses of their processes during the project and we saw evidence of higher order thinking and communication skills. Moreover, unlike Venville et al. (2008), we found the TCs were articulate in their analyses of the benefits and limitations of integration, as well as their understanding of integration as a pedagogy. We wondered about this difference in the outcomes of the two studies and suggest a possible explanation. In the case of Venville et al. (2008), their participants were in-service teachers who, with limited professional development, were asked by their administering bodies to incorporate integration into their existing practice. In our case, the participants were still developing their practice. Over the course of five to six weeks they were encouraged and supported in learning about, and experiencing, integration first hand.

4. An integrated project can impact practice and program positively.

The integrated assignment supported my (Astrid's) belief that science learning requires context; in this case the art construction allowed the TCs to develop a context for the science concepts, and transform an imagined concept into an artistic rendering. I have appreciated the disruption of my practice and have seen the value of the integration assignment for the TCs. I also realized that a collaboration of this nature had personal benefits: it provided opportunities to develop stronger collegial and personal relationships with my students and with Liz. Thus, I am eager to maintain this component of the course.

Like Astrid, I (Liz) found value in this project. I learned much about working with another educator to plan, implement, and assess an integrated project. As well, I feel the TCs had a balance of subject-specific knowledge and integration experience; for example, they learned basic content, skills, and teaching strategies in both subject areas before blending them in their project.

Three Essential Elements

Our exploration of art/science integration in a school of education led us to identify three essential elements (see Figure 2) we found to be important to the success of an integration project, especially at the tertiary level. First, at this point in our understanding, we believe any combination of subject areas is possible; however, a point of commonality or overlap must be identified or created. Admittedly, some subjects seem more obvious partners and so are more commonly matched (e.g., language arts and visual arts), but this should not deter the creative educator, keeping in mind that the human brain thrives on connections. We tried to ensure both disciplines were treated equally in this project. That said, for integration to occur successfully, we suggest the balance does not have to be equal but some emphasis be given to each subject at different times an integrated project.

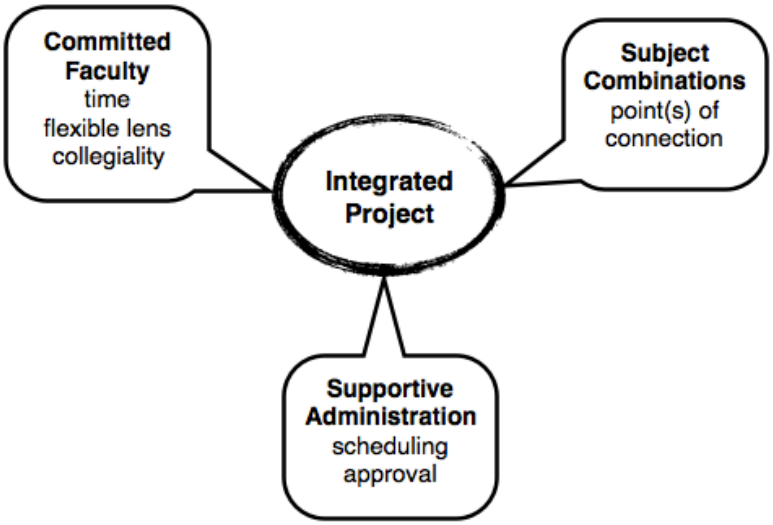

Figure 2: Three elements necessary for successful integration of diverse subjects

Second, the tertiary level of education presents some inherent obstacles to integration efforts, and here we find ourselves in accordance with Venville et al. (2008) and Wallace et al. (2007) in the supports that must be in place: two or more faculty must be committed to the integration, and their commitment must encompass several elements: a) willingness to give time to design and implement the project; b) willingness to view and re-view their program/course/ assignments/syllabus through a flexible lens that will accommodate change, that is, to be reflective educators; and, c) willingness to work respectfully and collegially through the challenges that will arise.

Third, the support of administrators is crucial. Given the complex timetabling found in most teacher education programs that adhere to "siloed" disciplines, the approval and assistance of those who control course scheduling is essential. Timetables must align so TCs are taking the integrated courses concurrently, and faculty members are able to participate in others' classes as necessary.

Although our study focused on two subjects, in one division, within a pre-service program at one university, it could be applied to professional programs beyond teacher education. We anticipate, as we explore integration at the tertiary level further, our understanding of the elements necessary for success will become more comprehensive and we will be able to provide refined recommendations.

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Conclusions

This exploratory science/art integration project provided an informative and stimulating opportunity for us to develop and model cross-curricular integration. The TCs learned scientific and art concepts concurrently, expressed them visually, and later reflected on the process. They also broadened their pedagogical and practical knowledge through experiencing, and overcoming, challenges in the different stages of the project. Overall, the project created a culture of new ideas that were carefully designed and implemented.

As researchers, we found the reflection papers helpful as they provided a window into how TCs perceived integration in general, their views of science and art, and their thoughts on potential classroom considerations if/when they do similar projects with their future students. This study provides a springboard for research in multiple directions: exploring art/science integration with other TCs (e.g., those in the P/J and/or I/S divisions), broadening the scope of data collection, and integrating art and/or science with other subject areas in the school of education and/or other faculties. Additionally, we would be interested to follow TCs into the classroom in order to observe integration projects there.

The project has also led us to think more categorically about the practical and pedagogical necessities required for integration. As a result, we have identified what seem to be the three important elements necessary for integrated projects. Finally, we welcome the opportunity to work with other colleagues, as we have seen the personal and professional benefits of the project for our TCs and for ourselves.

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